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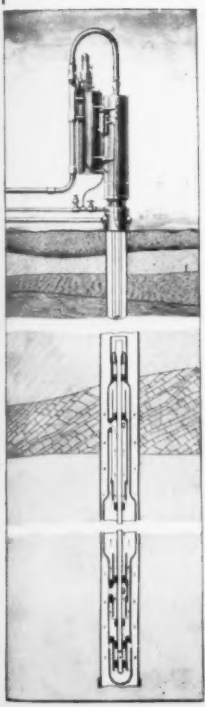

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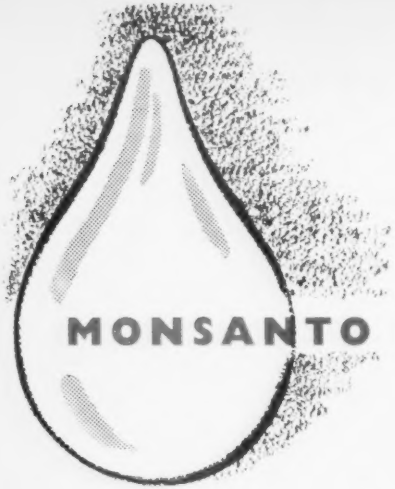

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PRESSURE VESSELS

By A. C. VIVIAN (Fellow)

THIS is a summary of a talk given to the South Wales Branch of the Institute at Llandarcy on November 2, 1948, with R. B. Southall, chairman of the branch and general manager of National Oil Refineries Ltd., presiding.

The primary purpose of the lecture was to present a description of the methods of manufacture and to show by means of slides and photographs a number of examples of pressure vessels, the scope being limited to steel vessels subjected to internal pressure in use in refinery equipment, vessels used in oilfields' production, and high-pressure pipelines.

The talk commenced with an account of some tests to destruction on a number of large diameter steel pipes, and the simple theory for calculating the bursting pressure. Though this was not the chief purpose of the talk, great importance was laid on the simple theory because, in the lecturer's view, the subject has been so greatly complicated by abstruse mathematical theory as to have rendered it quite unnecessarily obscure to the great body of users of pressure vessels in oilfields and refineries.

Fig. 1 shows a view of a 3-ft dia steel pipe burst by internal pressure, the ends having been previously closed in a large press. Measurements taken round the circumference at intervals along the length are given in Table I. It will be

Fig. 1.—A 3-ft drain-pipe burst by internal pressure.

TABLE I

TEST ON 3-FT DIA STEEL PIPE
SOUTH DURHAM STEEL & IRON CO. LTD.

Measurements taken round the circumference at every 3 inches approximately

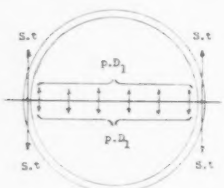
Position	*Before test* ft in	*After test* ft in	*Approx. elongation on circumference* in
1	9 7	9 7⅛	⅛
2	9 7⅛	9 9½	2⅜
3	9 7	9 11⅛	4⅛
4	9 7⅛	10 0⅜	5⅜
5	Inlet Connexion		—
6	9 7	10 1½	6½
7	9 7	10 1⅞	6⅞
8	9 7	10 2⅛	7⅛
9	9 7	10 2⅜	7⅜
10	9 7⅛	10 2½	7½
11	9 7⅛	10 3	7⅞
12	9 7⅛	10 3⅛	8⅛
13	9 7⅛	10 3½	8⅜
14	9 7⅛	10 3⅝	8½
15	9 7⅛	10 3⅞	8¾
16	9 7⅛	10 3⅞	8⅞
17	9 7⅛	10 3⅞	8⅞
18	9 7⅛	10 3⅞	8⅞
19	9 7⅛	10 3⅞	8⅞
20	9 7⅛	10 3⅞	8⅞
21	9 7	10 3½	8½
22	9 7⅛	10 3⅜	8⅜
23	9 7⅛	10 3⅜	8⅜
24	9 7⅛	10 3⅜	8⅜
25	9 7⅛	10 3¼	8⅛
26	9 7⅛	10 3¼	8⅛
27	9 7⅛	10 3	7⅞
28	9 7⅛	10 3	7⅞
29	9 7⅛	10 2⅝	7⅜
30	9 7⅛	10 2½	7⅜
31	9 7⅛	10 1½	6⅜
32	Pressure Connexion		—
33	9 7⅛	10 0¼	5⅛
34	9 7⅛	9 10⅝	3½
35	9 7½	9 7¾	⅛

noted that at burst the circumference has increased by over eight inches, i.e., by 7½ per cent. In other words, the circumferential strain and equally, of course, the diametral strain at burst was 0·075. The failure occurred where a pad had been welded to the surface of the pipe, that is, where the metal thickness had been increased. Without any abstruse knowledge of stresses or strains, certain quite simple conclusions can be drawn:

1. *The diametral strain (strain being increase in length divided by original length) can be measured accurately with a steel tape, since the increase was in the order of eight inches, and an error of* 1/32 *inch in measurement would only produce an error of* 0·25 *per cent.*

2. *The internal pressure produces a tension in the steel wall, and it is reasonable to assume that any circumferential ring of steel in the wall of the pipe behaves as a steel bar in direct tension. This simple explanation is frowned upon by mathematical purists, but is sufficiently exact for all practical purposes.*

3. *The ring of steel wall which included the pad where the failure occurred had to stretch to carry its share of the load, and as the bit where the pad was welded on*



CIRCUMFERENTIAL LOAD ON UNIT LENGTH

$$2 \cdot S \cdot t = p \cdot D_i \text{ approx.}$$

$$p = \frac{2 \cdot S \cdot t}{D_i} \text{ approx.}$$

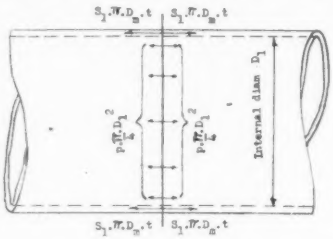
Actually the internal dia. becomes $D_i (1 + X)$, where X = strain inside. i.e.

$$t = \frac{p \, D_i \cdot (1 + X)}{2 \cdot S}$$

API-ASME Code.

$$t = \frac{p \cdot D_m}{2 \cdot S \cdot E} + c$$

Where D_m = mean dia., E = joint efficiency and c = corrosion allowance.



LONGITUDINAL LOAD ON CROSS-SECTION

$$S_1 \cdot \pi \cdot D_m \cdot t = \frac{p \cdot \pi \cdot D_i^2}{4} \text{ approx.}$$

$$p = \frac{4 \cdot S_1 \cdot t}{D_i} \text{ approx.}$$

That is, the longitudinal stress S_1 in the wall of the vessel is approximately half the circumferential stress, S.

Fig. 2

did not stretch because it was so much thicker, the rest of the ring had to stretch more. In fact, it stretched locally to failure close to the pad.

Fig. 2 is the diagrammatic and mathematical representation of the relation between the stress in the walls of the steel vessel and the internal pressure, as described in (2) above. The symbol S for stress (load divided by cross-sectional area) has been used to conform with the same symbol used in the A.P.I.-A.S.M.E. Code.

The wall thickness formula according to the A.P.I.-A.S.M.E. Code is stated in Fig. 2. It will be seen that the mean diameter D_m (where $D_m = D_1 + t$) is used in the code. This is an approximation to $D_1(1 + X)$, where X = circumferential strain. $D_1 + t$ is sufficiently accurate for most practical purposes.

The formula includes an allowance for corrosion, which may be 1/32 or 1/16 in, according to the anticipated severity of attack and expected life of the vessel. The formula includes also a joint efficiency and the A.P.I.-A.S.M.E. Code prescribes the value of the efficiency factor which must be used for various grades of welded joint. A double welded butt joint in a Class I vessel in which the welding is X-rayed and stress-relieved is accorded a joint efficiency of 95 per cent.

It is arguable that a butt weld (in a pressure vessel of Class I construction) which has been ground flush with the walls and which has been stress-relieved, and which has successfully passed the X-ray test is as strong as the parent plate and should have a joint efficiency of 100 per cent.

The genuineness of the simple principle upon which the formula

$$t = p \,.\, D_1(1 + X)/2 \,.\, S$$

is based is demonstrated by the calculated results given in Table II. The lecturer was indebted to the South Durham Steel & Iron Company for the data contained in Tables I and II. The latter contains a summary of tests to destruction on pipes of diameters varying from 2 ft 7½ in to 4 ft 1 in. The last two columns are calculations made by the lecturer from the measured data. Seven of the eight results are consistent with the steel used and the method of calculating set out in Fig. 2. The reason for the high calculated stress of one result is not known, the steel used being stated to be in the category of 24 to 28 ton/sq. in. The formula, however, is on the safe side, since by using it the thickness required for a given bursting pressure would have been computed in that particular case to have been a little more than the minimum required.

TABLE II
BURSTING TEST DATA
SUPPLIED BY SOUTH DURHAM STEEL & IRON CO. LTD.

Drg. No.	*Type of weld*	*O. dia in*	*Wall thickness in*	*Remarks*	*Bursting pressure p.s.i.*	*Max. strain*	*Stress, S, ton/sq. in.*
P977	Water gas	31¼	11/16	Burst along weld	2250	0·065	23·5
P990	Water gas	45	½	Burst along weld	1160	0·075	24·5
P991	Water gas	37	7/16	Flange failed	1200	0·047	23·1
P915	Electrical	40	15/32	Burst adjacent to weld	1240	0·049	25·9
P1065	Electrical	49	½	Flange failed	1200	0·128	29·0
P1083	Electrical	49	½	Flange failed	1150	0·091	26·9
	Electrical	36⅝	7/16	Burst at inlet connexion	1240	0·075	34·2
	Water gas	31½	11/16	Burst along weld	1480	0·080	25·0

Last column calculated from formula:

$$S = \frac{p \,.\, D \,.\, (1 + X)}{4480 \,.\, t} \text{ tons/sq. in.}$$

where p = internal pressure at burst in p.s.i.
D = internal diameter in inches.
X = circumferential strain.
t = wall thickness in inches.
S = hoop stress, ton/sq. in.

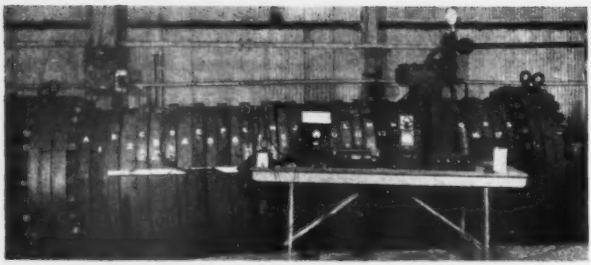


Fig. 3.—A banded pressure vessel tested to destruction.

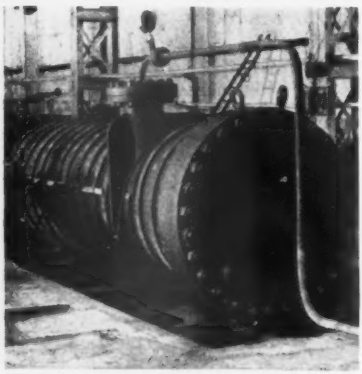


Fig. 4.—The tangential inlet on the vessel in Fig. 3.

Fig. 5.—A close-up of the fracture in the strengthening rib.

As evidenced by Tables I and II, the steel used is a ductile material and attention is drawn to a particular point which is not always appreciated, that when ductile steel is used the load inside a pressure vessel increases (as the steel stretches) by more than the amount corresponding with the increase in pressure. Thus, the simple formula

$$p = 2 . S . t / D$$

becomes

$$p = 2 . S . t / D(1 + X)$$

to cover this stretch, where X = circumferential strain.

There is no serious difference of opinion as to the validity of the simple mean diameter formula previously quoted for calculating bursting pressure. In fact, because steel is a ductile material, stress is evened throughout the walls for all but very thick-walled vessels, and the simplest formula will do.

The point on which controversy is focused is the criterion by which the correct steel should be selected, having in mind such considerations as the withstanding of alternating stresses, the matter of strain hardening, the effect of discontinuities or "stress-raisers" in the pressure vessel at inlets, drain holes, and so on. The lecturer advanced the view, which he has held for many years, that a physical "yardstick" is required, and that the "yardstick" is effective ductility or the amount which a parallel bar of the steel under consideration can be stretched, at the appropriate rate of loading, in a tensile test with a rising load before it begins to "neck" to failure and the load begins to decrease. This quantity is by no means the same as the percentage elongation which is the standard of tensile tests. Effective ductility

can be determined by simple measurements, but at a slightly greater cost than the percentage elongation.

Fig. 3 shows a banded pressure vessel 4 ft diameter and 14 ft 6 in long, before testing to destruction by the South Durham Steel & Iron Co., and Fig. 4 shows the 12-in diameter tangential inlet more clearly. Fig. 5 shows the fracture which occurred in the circumferential strengthening rib at the tangential inlet when the vessel burst at an internal pressure of 2400 p.s.i., and Fig. 6 the fracture in the core pipe adjacent to the welded pad. These fractures occurred simultaneously, so far as could be observed. The core pipe was $\frac{1}{2}$ in thick and would have burst at approximately 1200 p.s.i. had it not been strengthened to twice that bursting pressure by the bands.

Under these conditions the longitudinal stress at failure is not approximately one-half of the circumferential stress, as in Fig. 2, which applies to a plain walled vessel, but is equal or nearly equal to the circumferential stress in the case of the banded vessel. A great deal of useful data was obtained on the plastic deformation of steel from this banded vessel destruction test.

Fig. 7 shows the inside of the core pipe after plastic deformation.

Thick-Walled Vessels

The above remarks referred to thin-walled vessels. A thick-walled vessel is defined as one in which the wall thickness is greater than 10 per cent of the diameter.

At temperatures up to 650° F an internal pressure of over 2000 p.s.i. requires a thick-walled vessel. At 1000° F an internal pressure of over 500 p.s.i. demands it.

Comparatively few vessels in most oil refineries and oilfields come within the range of thick-walled vessels. An expression for calculating the thickness of thick-walled vessels is provided by the code based on the Lamé formula.

Codes of Practice

Reference was made to Dr Dorey's

Fig. 6.—The fracture in the core pipe close to the welded pad.

"Note on design stresses"* in which was summarized in graphical form a comparison of the various codes issued by a number of authorities. Reference was also made to a paper by E. J. Heeley presented at the same time and reproduced in the same publication.

The A.P.I.-A.S.M.E. Code is to a great extent used for unfired pressure vessels for oil refinery and oilfield vessels. The 4th edition (1943) is subdivided into five sections, the first, with reference prefix W, covering the design and construction of fusion-welded vessels, and the second with reference EW similarly but for vessels subject to external pressure. Section R covers the design and construction of riveted vessels, and section F the design and construction of integrally forged vessels.

The last section, I, covers inspection, repair, and allowable working pressures for vessels in service. This section includes the prescribed way of determining

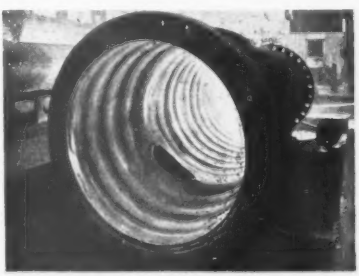


Fig. 7.—The inside of the core pipe after plastic deformation.

* *Proc. Instn mech. Engrs*, 1944, **154**, 32–3.

how long a pressure vessel may be kept on stream before a major shutdown for inspection and reassessment of working pressure is required, that is, the life before the next inspection.

Strength of Steel

A number of observations were made on the strength of steel and have mostly been mentioned above. A slide was shown at the end of the lecture of the design of an experimental banded vessel based on the measurements obtained during the South Durham test previously described. The vessel is now in course of manufacture and embodies certain features which may be of interest. It is 4 ft 6 in dia × 10 ft long, with a Vickers-Anderson type of joint instead of the very massive flanges usual with this class of vessel. The vessel is being constructed of D.W. steel (carbon about 0·22, manganese about 1·5) with bands 8 in wide and having 8-in spaces between them, a core pipe with 15/16-in walls, and bands 1¾ in thick.

Tensile tests will be made on test pieces cut from the same plates and subjected to the same heat treatment, and the bursting pressure (which will be in the order of 4500 p.s.i.), and the plastic deformation of core pipe and bands at high internal pressures will be calculated. The vessel will then be tested to destruction to determine whether the calculations accord reasonably with the measurements obtained. The object of the test is twofold. One is to find a substitute, if possible, for bolted flanges which become excessively heavy for these large pressure vessels, and the other is to establish, if possible, a method of computation based on bursting pressure and plastic deformation so that in the future design of such vessels, more being known about their behaviour at high internal pressures, the factor of safety (or, as it should more properly be called, the factor of uncertainty) may be reduced and economy in the use of steel achieved.

Discussion

Dr Hugh O'Neill (of Swansea University), H. N. Pemberton (of Lloyd's), H. C. Brown (of Ocean Accident), and E. Thornton (of National Oil Refineries) were amongst those who contributed to the discussion which followed. The multiplicity of codes and the desirability of unifying them; the new British Standard draft code; the importance of taking fatigue conditions of steel into consideration; the pros and cons of dealing with true stress or nominal stress; the fact that practically no departure from complete permanence of dimensions is a necessity for many machines and structures; and the importance of precise knowledge to replace the factor of ignorance were among the many aspects touched upon.

Mr G. E. Hider, the chairman of the South Wales Branch of the Institution of Mechanical Engineers, moved a vote of thanks to the lecturer.

SOUTH WALES A.G.M.

The Annual General Meeting of the South Wales Branch of the Institute was held at Llandarcy on February 4, 1949.

The chairman, R. B. Southall, commented upon the substantial increase in corporate membership and hoped that this increase would continue. The total branch membership at December 31, 1948, was 118, made up of 47 branch, 46 corporate, and 25 student members.

The committee for 1949 was declared elected as follows: P. F. Ellis; J. A. Green; E. J. Harley; J. L. Murray; T. F. Perry, R. B. Southall; E. S. Squire; D. W. Thomas; E. Thornton.

The meeting concluded with a vote of thanks to the catering staff of National Oil Refineries Ltd. in appreciation of their efforts prior to the branch meetings; to the hon auditors, Messrs C. E. and E. J. Jones, who were re-elected; to E. J. Harley, the hon secretary; the branch reporter, D. W. Thomas; and to the chairman.

Oil areas of the East Indies

THE SERIA OILFIELD

THE Seria oilfield, in British Borneo, was discovered in 1929 and is a most important oil-producing area of the British Commonwealth. In 1938 its crude oil output, including that of the Miri field in Sarawak, was 914,000 metric tons. During the war its production twice ceased—once when the Japanese invaded the East Indies in 1941 and again when the Allies reoccupied the islands in 1945. In the past three years, production has risen from nothing to a rate of 3,000,000 tons a year.

CRUDE OIL

Two types of crude are produced, one waxy and the other non-waxy, the former predominating. Rather more than half of the crude is processed at the Lutong refinery, the balance being shipped to Shell's refineries in Indonesia and Australia.

DRILLING

At the time of the Japanese invasion in 1941, some 150 wells had been drilled on the land and in the sea. The field,

Bombed storage tanks at Seria with new tanks in the background.

A blow-out in the Seria field in May 1948. The crater covered 1300 sq yds and was 10 ft deep.

which is operated by the British Malayan Petroleum Co. Ltd., a Royal Dutch-Shell subsidiary, extended for more than five miles along the shore and nearly a mile inland. Off-shore wells had been drilled from jetties extending up to 800 ft out to sea and directional drilling had been employed to deviate some wells several hundred feet farther seawards.

Devastation and Rehabilitation

When the invasion came in 1941, plans prepared as early as 1937 to deny the oil to the enemy were put into effect. Plant and equipment were immobilized or shipped overseas, wells were plugged with cement or otherwise rendered useless, and the area was evacuated.

The Japs attempted to restore productivity, but met with indifferent success. When they were swept out by Australian forces in 1945, they left a trail of utter destruction, and the troops, with the help of Shell technicians, had to tackle thirty-seven separate oil-well fires. Three months after the first fires had been lit, the last well was brought under control.

Drilling had been started by the end of 1945 and crude oil shipments by March 1946. As materials and equipment arrived from the U.K. and the U.S.A., wells were brought back into production, new wells were drilled, and additional pipelines (including two 3-mile submarine loading lines) were laid. The Lutong refinery was repaired where possible and a complete new plant from the U.S.A. was erected.

Shopping in the Commissary at Seria.

The hospital at Kuala Belait.

THE COUNCIL AND OFFICERS OF THE INSTITUTE, 1949-50

PRESIDENT

At the Annual General Meeting of the Institute on April 27, the suggestion that E. A. Evans, M.I.Mech.E., F.R.I.C., be re-elected as president for the session 1949–50 was unanimously approved.

VICE-PRESIDENTS

At the same meeting the Council nominated three vice-presidents for re-election—Dr E. B. Evans, H. Hyams, and C. A. P. Southwell—and three new vice-presidents, as follows:

M. A. L. Banks, B.Sc., F.R.I.C., who, since his election to the Council in 1945, has given considerable service to the Institute in the onerous position of chairman of the Election Committee. He has also served as a member of the House Committee.

M. A. L. Banks.

Following his graduation in general chemical technology at the Manchester College of Technology in 1922, he carried out in 1923–4 research work on coal under Dr R. Lessing, under a Research Fellowship of the Department of Scientific and Industrial Research.

In 1924 he joined the Anglo-Iranian Oil Co. Ltd., and was posted to the Llandarcy refinery of National Oil Refineries Ltd. until 1930. In the latter year he went to Abadan, where he remained until his return to London in 1933.

At present Mr Banks is manager of the Operations Branch of the Refineries Division of Anglo-Iranian.

E. J. Dunstan, M.Sc., M.I.Chem.E., who was first elected to the Council in 1945 and has been very active in Institute affairs, not only as chairman of the Northern Branch, but as member of the Branches, the Election, and the Research committees.

E. J. Dunstan.

After five years' service in World War I, Mr Dunstan graduated with honours at Birmingham University, and two years later was awarded the M.Sc. on a thesis.

He joined the Shell organization, first as works chemist, and was later appointed refinery manager. Mr Dunstan joined the Manchester Oil Refinery Ltd. in 1938 as refinery manager; he was appointed to the Board of Directors in May 1943 and became general manager of the company early in 1947. He is also consultant to Petrocarbon Ltd. and Petrochemicals Ltd.

In addition to his work for the Institute of Petroleum, Mr Dunstan has this year been elected chairman of the Northwestern Branch of the Institution of Chemical Engineers, and he is also on the committee of the Manchester Section of the Society of Chemical Industry.

J. S. Parker, M.A., B.Sc., a member of Council since 1945, following five years as an *ex officio* member, is particularly well known for his branch activity. He was in fact a founder member

Jas. S. Parker.

of the Trinidad, the Northern, and the Stanlow branches, as well as being a member of the original committee of each and chairman in the case of Stanlow.

Mr Parker joined the Anglo-Saxon Petroleum Co. Ltd. in 1919 at Suez refinery and, after a spell in the Indian Civil Service in 1920, elected to remain in oil and was loaned to United British Oilfields of Trinidad Ltd. as refinery manager in 1921. In 1930 he returned to Suez refinery, and in 1934 joined Lobitos Oilfields Ltd. as refinery manager at their Ellesmere Port refinery, where he still is.

He has given considerable service to the Institute, not only in the formation of branches, but as a committee member and is serving on the following committees: Branches, By-laws, Education, Engineering, Publications, Public Relations and Standardization.

Mr Parker has contributed to petroleum literature both under his own name and under his pseudonym "Yimkin" (Arabic for "perhaps"). In Trinidad he produced (as and when the co-editors felt like it) an oilfield magazine known as *It*.

During the last war, J. S. Parker was responsible for the refining of Britain's indigenous crude oil.

In addition to his academic qualifications of M.A. and B.Sc., Mr Parker is also a Ramsay Memorial Prizeman in Astronomy, an out-of-the-way qualification in petroleum circles held by at least one other member of the Institute—the technical secretary.

Hon. Treasurer and Hon. Secretary

G. H. Coxon and C. Chilvers, B.Sc., F.R.I.C., were unanimously re-elected as honorary treasurer and honorary secretary respectively.

Council

As the result of the ballot, the following were declared elected to the Council:

V. Biske, LL.B., B.Sc., F.R.I.C., research chemist, Lobitos Oilfields Ltd.

C. D. Brewer, M.I.Mech.E., engineer in charge of research, Engine Services Section, Thornton Research Centre, "Shell" Refining & Marketing Co. Ltd.

F. L. Garton, M.A., B.Sc., A.R.I.C., in charge (acting) of Sales Technical Advisory Dept., Shell Petroleum Co. Ltd.

H. S. Gibson, C.B.E., M.A., M.I.Mech.E., formerly general fields manager, Anglo-Iranian Oil Co. Ltd.

J. A. Oriel, C.B.E., M.C., M.A., F.R.I.C., M.I.Chem.E., F.Inst.F., general manager, "Shell" Refining & Marketing Co. Ltd.

R. B. Southall, general manager, National Oil Refineries Ltd.

H. C. Tett, B.Sc., A.R.C.S., D.I.C., F.Inst.P., A.M.I.Mech.E., general sales manager, Anglo-American Oil Co. Ltd.

The existing members of Council not requiring re-election were:

W. S. Ault, B.A.
C. T. Brunner, M.A.
T. F. Laurie.
F. Morton, Ph.D., F.R.I.C.
H. E. F. Pracy, B.A.
D. L. Samuel, B.Sc., A.R.I.C.
G. H. Smith, Ph.D.
E. Stokoe.
E. J. Sturgess, B.Sc.
G. H. Thornley, M.Sc.
E. Thornton, B.Sc., F.R.I.C.
H. de Wilde, M.Sc., M.I.Mech.E.
A. T. Wilford, B.Sc., A.R.I.C.
W. J. Wilson, F.R.I.C., A.C.G.I.

The following were elected on the nomination of the Council as *ex officio* members of Council to represent the branches:

A. Fleming (Scottish Branch).
A. J. Goodfellow (London Branch).
J. G. Hancock (Stanlow Branch).
N. E. F. Hitchcock (London Branch).
E. J. Horley (South Wales Branch).
T. W. Ranson (Northern Branch).

Reprints of an article on "The petroleum chemicals industry in the U.K." by W. E. Huggett are available from Public Relations Dept., Petrochemicals Ltd., 44A Dover Street, London, W.1.

RANDOM RECOLLECTIONS

By JAS. S. PARKER (Fellow)

NORTH and South America are connected by the comparatively narrow Panama land strip. In consequence, the majority of the north–south air traffic funnels through Balboa. The airport is modern. Massive glass electric-eye controlled entrance doors leave the uninitiated with outstretched hand in mid-air.

Money, to anyone from the sterling area, is a source of mental gymnastics abroad. The main concern of many South American countries, both on entering and leaving, is the state of one's finances. In view of the allowances granted, this is no less a concern to the traveller.

Panama City is across the street from Balboa. One is Panamanian, the other under U.S. jurisdiction. As far as visible or physical restrictions are concerned they are one and the same town.

One recalls black dark over the Andes; to some exciting, to others an overworked air steward; Cali, in Columbia, with purple cattelaya orchids in cellophane packs; Quito, in Ecuador, with its short, sturdy, broad-chested Indians; oversized lungs, fitting in the rarefied atmosphere, fatal in the lowlands; Guayaquil, in Ecuador, with its tropical humidity; Talara, in Peru, in the centre of a long, narrow, desert coastal strip.

The north Peruvian coastal strip which contains the oil-bearing strata is carpeted with seashells and coral. On it can be found the skeletons of whales. This under-sea evidence is on a plateau 1000 feet above sea-level. The plateau rises steeply from a thin strip of beach bordering the Pacific Ocean.

The presence of the cold Humboldt current close inshore at this most easterly part of South America makes fishing attractive, bathing pleasant, and rainfall negligible. The plateau across to the Andes foothills is, in consequence, desert.

The wadis of the Middle East become the quebradas of the Peruvian coastal strip. These are dry water-courses which in the limited rainy season may become inconveniently wet. There the similarity ends, as the quebradas, unlike the wadis, are cut out from the 1000-foot plateau, simulating huge cracks.

Transport across the oilfields has its ups and its downs, the transition giving rise to numerous hairpin bends which are probably less awe-inspiring when one gets to know them. Familiarity breeds contempt, so South American practice is to utilize as a roadside

Drilling in the more rugged quebradas of Peru presents a man-sized transport problem.

Over 80 wells are connected to the eccentric on this "catalina".

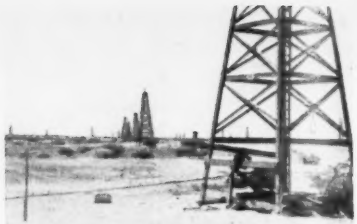
monument the wreck of the vehicle which beat the hairpin speed record.

The original oilwells in Peru were drilled at sea-level on or near the beaches. The majority of the present wells—shallow, mainly pumpers—are on the plateau. Drilling in the more rugged quebradas is a man-sized transport job worthy of the visitor interest which it engenders. As in the Caribbean, the trend is to keep drilling, utilizing diesel-driven rigs.

The desert coastal strip of Peru continues north across the mouth of the river Guayaquil into Ecuador, where it is again oil-bearing.

It is as difficult these days to get out of certain South American countries as it is to get into them.

The truck-transportable type of drilling rig is extensively used.



The majority of the Peruvian wells, mainly pumpers, are in the plateau.

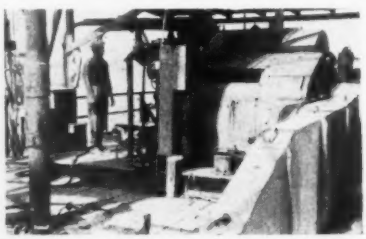
From Guayaquil to Santa Elena is about 150 kilometres, and in that comparatively short distance one passes from lush tropical vegetation to sparse desert scrub. The oil naturally is in the desert scrub.

These days it is newsworthy that over "Reception" in the main Guayaquil hotel there hang framed pictures of our King and Queen. The owner is from Gibraltar and proud of his British nationality.

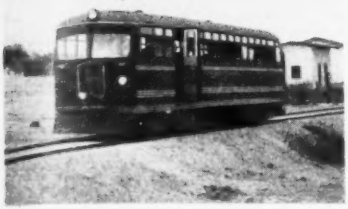
All passenger-carrying vehicles in Guayaquil, which are mainly of charabanc type, are provided with radios. Both vehicle and radio proceed at full throttle.

Guayaquil appeared to have more than its share of roadside kiosks peddling a well-advertised American drink. Sales progress could be estimated from the extent of the metal bottle-top paving of the bitumen impregnated roadways in the vicinity of the kiosk.

The railway from Guayaquil to Santa Elena with terminus at Salinas is built



The trend, as in the Caribbean, is to deep drilling, utilizing diesel-driven rigs.



The Ecuadorian railway—a charabanc on railway wheels.

round the petrol engine. The coaches are best described as charabancs on railway wheels. The "engine" driver sits in the normal bucket seat twiddling the normal steering-wheel. The steering-wheel puts on the brakes, a not infrequent necessity whilst chasing cattle, asses, or goats off the lines.

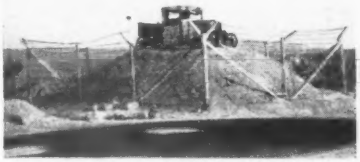
Salinas is the Lido of Ecuador. It is also as the name indicates, the producing end of the Government salt monopoly.

There are numerous hand-dug wells still producing near Salinas.

Salt pans, set out for sun-heat evaporation, stretch for miles and are guarded from elevated watch-towers by armed guards.

Close to Salinas there are numerous hand-dug oil wells in production. These are about nine feet deep and bottomed by salt water with a layer of oil on top. The oil is skimmed off into barrels and sold by the natives to the local oil interests.

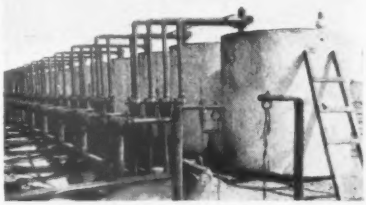
The oilfields in Peru and Ecuador obtain their fresh water by sea-water evaporation and condensation. The natives in the neighbourhood of Salinas, Ecuador, utilize wells which, it is said, date back to the days when Drake watered and provisioned his ships in this area. Their water transport method, a donkey pulling a rolling barrel, was probably originated about the same period.



The vehicle which beat the hairpin bend speed record.

The oilfield terrain in Peru and Ecuador is mainly flat scrub. The main producing levels are at 2000–3000 feet. Extensive use is thus made of the truck transportable type of drilling rig or the skid type.

The majority of the wells are pumpers, and all pumping operations are centralized on to suitably situated "catalinas". A central power unit drives a large eccentric wheel to which are connected cables stretching out to the pumping



The receiving tanks and manifold of the over 80-well "catalina".

This water transport method probably originated in Drake's days.

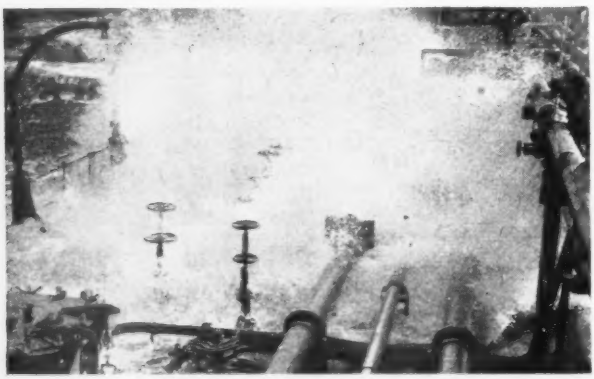
units on individual wells. A back and forward motion is transferred to the cable, which gives an up and down motion to the pumping beam on the well. In Ecuador, by a special under-slung arrangement of the actual power unit, over eighty wells are connected to the eccentric drive of one catalina.

One can be reasonably certain of picking out the American driller from the crowd. This becomes a certainty when five minutes after arrival at their airport destination all airport officials are smoking cigars.

It was the open season in the Caribbean for authors. Leo Walmsley was met in Curaçao gathering material for a book on tankers. Colonel Egerton of Mount Everest fame was met in Trinidad *en route* home after traversing the Caribbean islands. Rosita Forbes was following a similar trail.

Homeward bound in a fully loaded tanker with one foot of freeboard; a choppy sea spumes across the decks; the swimming-pool water becomes too cold even for the most hardy. Lloyds' signal from the Isle of Wight and early morning mists over the Thames mudflats are not quite so colourful as the Caribbean but still, home.

Finis.



Homeward bound!

Oertling Balances.—An interesting exhibition of balances was held in London recently by Messrs L. Oertling Ltd. At the opening, Dr G. F. Hodsman referred to the many improvements which had been made in design; in particular the use of corundum in place of agate for the bearing planes, and the design of the optical system in the prismatic reflector device.

REFINERY PROCESS COSTING*

By E. J. JONES (Associate Member)

How much does it cost? This is a question so often asked to-day, and yet the question as it stands is capable of many interpretations. The inquirer must be clear in his mind what cost he is asking for, and the supplier of the information must be equally clear as to the type of cost he is being asked to give. There are many types and varieties of costs, and to clarify the position at the outset, this article intends to deal with process costing as applied to the mineral oil industry. Its purpose is to give to the chemist and engineer some idea, in broad outline, of the data required and the method of preparation of cost statements. To those readers already engaged in costing, much will appear obvious, but none the less it is hoped that some ideas may be kindled. A detailed description of the work involved in recording the receipts and issues of stores and materials, or the method of preparing and paying wages, etc., has been deliberately avoided in order not to obscure the essential principles. It is only by the co-operation of all parties that the question "What is the process cost?" is properly asked and answered.

By this question is meant the cost of a particular process used in treating a particular oil product at any given point in refining, and is not to be confused with the cost of refining a given quantity of oil up to any particular point of processing. The problem is one of ascertaining the cost of distinct phases of treatment as applied to particular products. Thus the whole process of refining must be broken down into separate operations or departments, and most readers will appreciate the difficulty of this, particularly in view of the complexity of operations obtaining in the petroleum industry, as compared with many others. It is at this fundamental point that the technician's knowledge must be applied, so as to bring the requirements of processing and costing into harmony. In some cases a plant itself may be treated as a complete unit. On the other hand, a particular plant must be broken down into the particular products it serves, e.g., continuous washing plant. For ready and easy reference, to each operation or process is allocated a job number, and to each job number will be allocated the items of expense as they arise. The governing principle here is that "the sender pays". By this is meant that in allocating various charges, each process will take all the expense involved in actual processing, plus delivery, to the next process. Thus, to take a simple example, process "A", in addition to its own cost, will bear the expense of pumping and maintaining the pipeline to the inlet valve of the feed tank to process "B". Process "B" bears all the charges in respect of the feed tank, processing and delivery to process "C", and so on.

Here we must digress for a moment. It will be clear that amongst the breakdown of various operations will be those relating to services, i.e., steam, power, and water, etc. The cost of running these must be ascertained and a cost per unit of consumption obtained. This cost forms the basis of charging that particular service to the various processes. The consumption by each process may be ascertained by meter or by estimating; this may be based upon running hours, type of machine, or throughput basis. The allocation of these consumptions must receive the constant attention of the engineers, for if inaccuracies arise at this point, the cash values with which the accountant is concerned will be fallacious.

So far, the broad term "expenditure" has been used, and used advisedly. Only items of expense, as distinct from

* An Address to the South Wales Branch of the Institute of Petroleum on March 4, 1949.

financial loss, are involved. No allowance is made in respect of depreciation or capital charges in respect of plant and buildings, etc., the pros and cons of this highly controversial aspect being outside the purview of this article.

It will now be clearer to the reader if the main items of expense are dealt with individually, and their method of charging described.

Salaries

In any case, where a salaried official is engaged upon one plant or process, it is clear that his salary may be charged to that particular job. Where his activities are more varied, but within set limits, then a time factor is generally used, allocating to each job according to the time spent thereon. Should the refinery as a whole receive the attention of the individual, then his salary is charged to "Establishment charges", to which subject reference will be made later on.

Wages

The basis of charging this item is the time-sheet prepared by the employee after proper verification. The allocation of such wages to a particular plant is comparatively simple, but difficulties arise when attempting to charge wages to any particular grade of oil being processed. The method usually adopted is to "split" such wages on a running hour basis. It is as well at this point to appreciate that within limits, in the oil industry, wages bear little or no relationship to the quantity of oil processed. An operator is required, whether he turns a valve partially open or fully open, and so there is no link between the worker and his output. Thus, save in exceptional circumstances, a throughput or makes basis of allocating wages will lead to erroneous conclusions.

Materials

Under this heading are charged items specially ordered for a particular job or specific work done by a contractor. The order authorizing the purchase of the item or work to be done will normally provide the allocation to which the cost is to be charged. Here, again, co-operation between the technician and the accountant is essential.

In this connexion there is a point which requires further elaboration, and it is with regard to any very expensive material or job. Clearly, the period in which the bill is paid should not bear the cost; for the benefit sustained by the process is of a greater duration and in any case the inclusion in one sum would result in fallacious comparisons in the costs. To overcome this, it is customary for such heavy expenditure to be apportioned over the year or other agreed time, so that each costing period bears its fair proportion, thus enabling comparative costs to be objective.

Stores

The requisition on the stores forms the basis of allocating those charges, and so long as the plant or process requiring the items is clearly stated, no great difficulty is experienced in allocation. However, it is sometimes necessary to split the cost of stores, and this is also true of materials, over the products treated at a given point. This may be done by charging the cost relative to running hours or throughput, depending upon the relevant circumstances.

Chemicals

Ordinarily, the use of any chemical, purchased or manufactured, by any plant or process is capable of fairly exact measurement, and thus the cost thereof may be properly allocated to each job.

Fuel

Coal.—This is held on bulk stores charge and is issued to the various plants on stores requisition in the

normal way. These requisitions form the basis of allocation of cost.

Fuel Oil.—This is somewhat of a misnomer, and refers to residues and surplus distillates, etc., consumed at the refinery more or less as they arise. Consumptions are based upon engineering and process data. For costing purposes a valuation per ton ranges from a very nominal price to an approximate market price, depending upon the domestic policy of the company.

Cost statements, therefore, simply show the total collection of each type of expense for a given period—generally a calendar month—against each particular operation or process. The divisor is the make for that period, thus giving a cost per ton of processing a particular product during a stated period.

Earlier in this article, reference was made to Establishment charges, and it has been seen that such expenses are not taken into consideration when dealing with purely process costs. They are those of an indirect nature and are applicable to the refinery as a whole, and are incapable of precise allocation to any particular process or operation. These include certain salaries, office charges, general maintenance, rents, rates, insurance, and the like. From this it is clear that there is no direct connexion between such items and, say, the acid treatment of benzine. To attempt to introduce this expenditure would inevitably lead to unwarranted complications, and would disturb any attempt at comparable figures. Of course, such items would be included in any total cost, but the cost would not then be a process cost.

Rubery, Owen & Co. Ltd. of Darlaston, have moved their London office to Kent House, Market Place, Oxford Circus, W.1.

U.S. OIL SITUATION

Conviction that a healthy domestic producing industry must be maintained and assurance that the U.S.A. is not dependent upon foreign oil were expressed by Eugene Holman, president of Standard Oil Co. (New Jersey), February 7, in an exchange of letters with Governor Beauford H. Jester of Texas.

Governor Jester had objected to foreign oil imports on the ground, among others, that they had "seriously curtailed" the incentive for development and discovery of new domestic reserve.

In reply, Mr Holman pointed out that domestic oil production exceeded domestic consumption in 1948 by more than 400,000 brl daily and that a large percentage of this margin went to rebuilding stocks from their low level of a year ago.

Government statistics showing net imports of 144,000 brl daily in 1948 were not necessarily a clear guide to physical movements of oil between the U.S.A. and abroad, Mr. Holman stated. Though reported as imports, foreign oil used to bunker ships in foreign trade at U.S. ports did not enter trade in the U.S.A. Statistical "exports" reported by the Bureau of Mines did not include bunkers to foreign ships or military purchases in the U.S.A. which were shipped abroad.

Cutbacks in domestic production were not due to net imports of oil but to a combination of circumstances. These included tanks becoming full, foreign production approaching foreign consumption levels, and a record warm winter in the heavy eastern consumption areas which reduced domestic consumption below anticipations.

Mr Holman saw no cause for alarm in the future and estimated that the outlet for domestic crude to meet domestic consumption in 1949 would be about the same as the average production in 1948.

COUNCIL COMMENTARY

AT the April meeting of the Council a fairly good gathering dealt with a sizeable agenda covering very varied topics.

This was the last meeting of the Council as it has been constituted since the last election, and it was appropriate that there should be cheering news of a more hopeful financial situation than we have had for some time, though not by any means good enough to warrant any slackening of effort.

The chairman of the Finance Committee and the report of the Election Committee indicated a steady increase in the number of member companies, and an increase in the realization that the nominal minimum of £10 subscription was not a desirable maximum.

The efforts of the individual member will show when the proposed increase of subscription as from January 1, 1950, comes into effect, a proposal which received the blessing of the Council, and which should have been ratified by a Special General Meeting by the time this article is in print.

The ballot was quite encouraging, 25 per cent of the members having registered their votes and the result was satisfactory, expressing as it did continued confidence in old and tried servants and introducing at the same time new blood.

It is quite interesting to note that a considerable number of the present Council have graduated to elected membership from *ex officio* branch status, approximately one-third of the present Council having past or present connexions with the branches, a tribute to the unflagging efforts of that doughty fighter for branch interests, Mr J. A. Oriel, whose re-election is welcomed by all.

Incidentally, a letter from the Trinidad Branch about elections to membership indicates that the membership situation is still fluid, and neither the Institute nor the Council can be accused of being set in too rigid a pattern as long as this active interest continues.

The President continues active and alert in attending to the little courtesies on behalf of the Institute. This month's recipients of congratulations are Dr Sutherland, who was recently elected a fellow of the Royal Society, and Professor R. Linstead, who has succeeded Sir Ian Heilbron as Professor of Organic Chemistry at the Imperial College of Science.

Reports were received from Election, Engineering, and Finance committees and a statement from the Institute delegation which recently attended The Hague in connexion with a World Petroleum Congress to be held in 1951.

This statement indicated that decisions were reached that a conference should be held in 1951 at The Hague, that increased representation on the permanent council from various countries should be arranged (not at present including the Eastern *bloc*); that national committees should be encouraged in as many countries as possible to screen papers before passing forward; and that full publicity should be organized by these national committees for the conference itself.

Various matters were introduced by the President and other members as follows:

There is to be a French petroleum conference in June of this year; a World Power Conference and an Oil Shale and Cannel Coal Conference in July 1950, the former in London and the latter in Scotland; and in June 1951, one jointly arranged by the Institution of Mechanical Engineers, the Institution of Electrical Engineers, and the Institution of Civil Engineers, in connexion with the British Exhibition.

Mr Dewhurst brought a request from the Parliamentary and Scientific Committee for an address on the National

Programme of new refineries, a small *ad hoc* committee being formed and deputed to attend to this.

In response to a request for representation of the Institute of Petroleum, Mr E. Thornton was appointed delegate to the newly formed Education Committee of the Institute of Fuel.

The result of the ballot as shown by the recording officer, Mr Hyams, to fill the seven vacancies on the Council, was:

V. Biske
C. D. Brewer
F. L. Garton
H. S. Gibson
J. A. Oriel
R. B. Southall
H. C. Tett.

The President congratulated the successful candidates, and thanked retiring members on behalf of Council.

EMPIRE MINERALS

In his report for 1948, the director of the Imperial Institute, in the chapter on the Mineral Resources Department, records that inquiries have been made regarding the possible revival of the manjak industry of Barbados. If good quality material could be offered in the U.K. at competitive prices with gilsonite from dollar areas, a reasonable market might be established. However, samples submitted to possible buyers did not produce favourable reports.

JAMAICAN CLAYS.–Four samples from Jamaica were found to be of a subbentonitic nature and mixture of montmorillonite and illite. At least one showed promise as a petroleum catalyst, and their use in oil refining is under consideration.

ADEN SHALE.–One sample from Aden appeared likely to be an oil shale, but was too small for detailed examination.

T.E.L. AND ENGINE DESIGN

At its meeting on February 22, the London Branch had an interesting address on "The influence of tetraethyl lead on engine design and performance" by Air Commodore F. R. Banks, C.B., C.B.E. The lecturer began with an historical review of the discovery of detonation, as distinct from pre-ignition, in the early years of this century and the use of early anti-detonants such as Midgley's di-ethyl telluride. The search led to the advent of tetraethyl lead, immediately outstanding in its anti-knock properties but attended by certain ill-effects, particularly lead oxide deposits. The gradual conquest of these troubles by the addition of ethylene dibromide and ethylene dichloride, and by improved engine materials and valve and combustion chamber design, was then related in detail.

The author concluded with his constructive criticisms on automobile engine design and an extensive dissertation on modern antiquities in this field on both sides of the Atlantic.

A very keen session of questions followed to which Messrs A. W. Deller, R. D. Streeton, J. C. Jewell, P. Thistleton, C. D. Soltz, W. D. Davies, and V. H. Robinson contributed. Air Commodore Banks answered each individually in his lucid and easy style.

The paper has been published in the *Journal* of the Institute.

A landing craft converted into a dining-room for use by employees of John Howard & Co. Ltd. working on a 7-mile jetty near Damman for the Arabian-American Oil Co. The dining-room can seat 30 persons.

FIGHTING OIL FIRES

At a meeting of the Trinidad Branch of the Institute of Petroleum on July 9, 1948, H. L. Roberts, fire marshal of Trinidad Leaseholds Ltd., gave an address on "Fire fighting with particular reference to the oil industry."

Dealing first with the wartime organization of the British fire services, Mr Roberts said that fires in pipelines and storage tanks were similar in character and encountered all over the world.

The main requirement in this type of fire was, of course, the shutting off of the supply feeding the broken piping at the earliest possible moment. That was not the fireman's job; the fireman's problem was to put out the fire. Much depended on the actual location of the break in the line or lines of piping, but generally the fireman was faced with a fired and freed oil problem which, if the oil was not flowing, did not as a rule present too many difficulties in itself. The job became complicated and dangerous when other charged and unbroken lines were involved. Speed was then of the greatest importance, whilst at the same time the surrounding full lines had to be kept cool. It was possible under certain conditions to cool the lines and extinguish the fire with the spray or fog nozzles alone, but if both fog or spray nozzles and foam were used, great care had to be taken to ensure that the cooling jets did not prevent a blanket of foam forming over the fired and free oil.

A point that may have some interest to oil men was that soon after the formation of the N.F.S., chemical foam equipment was discarded and air or mechanical foam held at all points where oil fires seemed likely to occur. Probably one of the reasons for the change was the greater mobility of the mechanical foam as against chemical foam.

The oil industry, though well aware of the problems involved when large storages of their products were fired, was itself at times appalled by the situation which presented itself at big fires where, through bomb damage, the auxiliary services, not normally affected at a peacetime fire, were destroyed. Whole groups of tanks became directly affected, and in one case at Falmouth,* flowing oil from a split tank covered an area of 600 by 100 yards. This oil, well alight, destroyed everything in its path. The tank feeding this flow was of 4000 tons capacity and 118 feet in diameter. It was buried but the bomb that hit it detonated on impact disrupting the whole roof area, and threw out a considerable quantity of the spirit content. It says much for the fire fighters that they extinguished the fire in the product remaining in the tank in eight hours. The damage to the tank was, however, so severe that the spirit continued to flow away from the tank to feed the flowing fire. This was more difficult to deal with and dams were hastily constructed in an effort to stem the tide of burning spirit.

Another fire of interest to oilmen was that which occurred on the tanker *Liseta*† whilst she was in dock being steamed out after discharging a cargo of aviation spirit. A windsail had been rigged to one of the tanks, when a severe explosion occurred and was immediately followed by a second. The ship was opened from engine room to the forepeak. This explosion was immediately followed by a severe fire over practically the whole of the ship. The main trouble from the fireman's angle was the pockets of gas all over the shattered framework of the vessel. In this case they had first to wash out all these pockets, and get the gasoline down into the well of the ship where it was extinguished by the use of foam. There were many other interesting incidents and problems at this fire but the point to

* "Some notable wartime oil fires", V. G. Wilmoth, *J. Inst. Petrol.*, 1946, 32, 6; "Fires and explosions at oil installations", E. P. Lancashire, *J. Inst. Petrol.*, 1947, 33, 141.
† *J. Inst. Petrol.*, 1946, 32, 8.

remember here was that it was a peace-time fire, and might happen again if similar conditions were set up. The cause of the explosion was finally considered to be a loose steam hose line in operation over an open hatch creating a spark which ignited an explosive mixture in the tank.

Mr Roberts said that in recent years much had been heard of water fog, which had a definite place in fire-fighting equipment, although its limitations were such that alone it was seldom likely to be able to deal with an oil tank fire.

Where a fired tank was situated among others there were dangers of slop-overs and boil-overs. These had been very efficiently dealt with in the *Journal* of the Institute in March 1947.

In conclusion, Mr Roberts said that there was constant need for alertness in respect of fire hazards at all times within the industry. Fire prevention ranked high in the fields of oil production and processing. The availability, use, and care of fire equipment, together with a high standard of efficiency in the training of personnel in fire-fighting methods was of paramount importance in any well-run oil organization.

"Safety Measures in Chemical Laboratories."—This recent publication of the Chemical Research Laboratory of the D.S.I.R. should be a valuable adjunct in any chemical laboratory. It deals with the various hazards met with daily in the laboratory, and outlines safety and preventative measures and antidotes for persons affected by poisons, etc. Copies are obtainable from H.M. Stationery Office, price 7*d*., post free.

Colloidal Graphite.—Two pamphlets available from Acheson Colloids Ltd. (9 Gayfere Street, London, W.1) deal with (No. 94) the use of colloidal graphite in chipless metal-forming operations, and (No. 95) high-temperature lubrication.

PRACTICAL DEMONSTRATIONS IN SOUTH WALES

A series of practical demonstrations were given on March 4, 1949, by members of the technical staff of the National Oil Refineries Ltd., under the leadership of Dr J. W. Jones, to members of the South Wales Branch at Llandarcy.

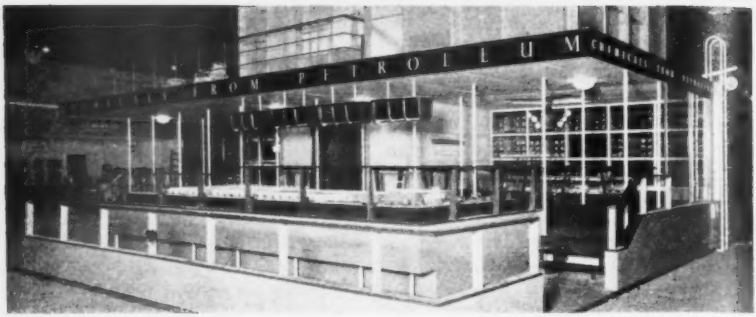
The demonstrations were intended primarily for the benefit of the non-technical members of the branch and were well received by a large gathering.

Experiments were given with gases, liquids, and solids and included the following:

Demonstrations of change of state; some properties of permanent and liquifiable gases; combustion and explosion of air/gas mixtures and flame propagation; comparison of gas densities; and diffusion of gases. Glass models showed the operation of a steam ejector; the flow of liquids through venturi tubes and orifice plates; the function of bubble caps; and the operation of an air lift for liquids. Examples of the elasticity and plasticity of solids were given and the use of projected microscopic examinations showed crystal structure and the results with ordinary and polarized light. There were examples of the suspension, dispersion, and flocculation of solids in liquids and comparisons of filtration and adsorption. Experiments demonstrated the vapour pressure of liquid hydrocarbons, surface tension of liquids, the significance and measurement of pH value, etc.

With each experiment its practical use in the petroleum industry was explained.

Head, Wrightson & Co. Ltd. have acquired the businesses of F. J. & L. Dean and of Aldean Designs Ltd. of Slough; and of D. J. Hawkins & Sons Ltd. of Henley-on-Thames. With their subsidiary, Head Wrightson Light Alloy Structures Ltd., these will be amalgamated as Head Wrightson Aldean Ltd. with headquarters at 61 Windsor Road, Slough, Bucks.



PETROLEUM AT THE B.I.F.

The new world in industrial endeavour which has been opened up by the development of chemicals from petroleum was the basis of Shell Chemicals Ltd. stand at the Olympia, London, section of the British Industries Fair.

On this stand, a picture of which heads this page, were scale models of the three sections of the Fair—Earl's Court and Olympia, London, and Castle Bromwich, Birmingham—each complete with exhibitors' stands. Behind each model was a series of panels bearing the names of various petroleum-based chemicals. As each panel was illuminated in turn, so was the group of stands covering the particular industry in which the chemicals were used.

Similarly, the chemicals which petroleum can supply for industry were also the subject of the stand occupied by Petrochemicals Ltd. On the stand of Monsanto Chemicals Ltd. was an attractive exhibit of petroleum chemicals, detergents, and additives for lubricants, while the Distillers Co. Ltd. illustrated the production of solvents from petroleum.

The Fullers' Earth Union Ltd. exhibited a full range of their activated earths for the treatment of mineral oils and waxes and for the regeneration of waste oils. This stand also showed samples of earths for use in rotary drilling fluid.

Her Majesty The Queen, accompanied by H.R.H. Princess Elizabeth, was particularly interested in the models.

COAL TAR DISTILLATION

At a meeting of the Scottish Branch of the Institute on March 23, under the chairmanship of Mr R. Crichton, an address on the "Coal tar distillation industry" was given by Colonel F. M. Potter, O.B.E., T.D. The address is summarized below.

Historical

Two hundred years ago (1749) saw the erection of the first milestone on the road of industrial chemical development in Scotland. In that year Dr John Roebuck of Carron fame founded his vitriol company at Prestonpans and in the same year was born Archibald Cochrane, 9th Earl of Dundonald, and founder of the British Tar Company, the first commercial project engaged in the evaluation of the by-products of coal carbonization and which by the end of the eighteenth century had works at Culross, Dalkeith, and Muirkirk. The objectives were the production of a coke to replace charcoal for the iron smelters, and a tar or pitch to compete with the Swedish product then so largely used in the shipyards. Sal ammoniac was already being manufactured in Scotland from soot collected by the tronmen—members of the Edinburgh Chimney Sweeps' Society—and the ammoniacal liquor from coal distillation served as a further source of raw material. When the company was being floated, Dr Joseph Black, the Professor of Chemistry at Edinburgh University, reported to Adam Smith on the practicability of the processes and on working costs and sales prospects for the process. Early success was followed by lean years, mainly due to the Admiralty for a number of years refusing to use the coal products on their ships, and operations ceased by 1830.

By this date the use of coal gas as a public utility, based on the work of another Scot, Murdoch, was extending, and uses had to be found for the by-product tar. Macintosh in Glasgow (1820) first used the tar naphtha as a rubber solvent in the preparation of waterproof fabrics; railway sleepers were impregnated with the coal tar creosote (1839); coal dust was briquetted with the pitch (1842); Mansfield prepared benzene from coal tar (1845); and Perkin discovered aniline mauve (1856), the forerunner of the long series of coal tar dyes available to-day. Lister in 1865 first used phenol as a disinfectant and then followed the synthesis of alizarine replacing the madder root dye and of indigo. The major developments of this century fall under the headings of road construction and surface preservation, dyes, plastics, home-produced motor fuels, and synthetic drugs.

Organization of the Industry

Since 1920 there has been a steady process of grouping within the industry and a growth of co-operative tar schemes, regional in character. About 50 per cent of the crude tar produced by gasworks and coke ovens is covered by these schemes and 25 per cent is distilled by these crude tar producers on their own works. The Scottish co-operative tar scheme distils two-thirds of the tar produced in Scotland. By agreement between the producer and distiller, the distiller provides the working capital and plant, and markets the products. After charging interest at a fixed rate on the distillers assets and meeting the working costs, the balance is divided between producer and distiller in agreed proportions on a sliding scale. Matters of policy are decided by a committee on which the producers have a majority of representatives.

A description was then given of typical plant used for the distillation of tar and the manufacture of the main products, such as pitch, creosote, benzole hydrocarbons, phenols, naphthalene, pyridine, anthracene, road tars, and tar fuel oils.

Research on the benzole hydrocarbons

is covered by the National Benzole Association, on the use of refined tar in road construction by the British Road Tar Association in co-operation with the D.S.I.R. Road Laboratory (which this year will be opening a branch laboratory at East Kilbride to study especially Scottish conditions), and finally by the D.S.I.R.-supported Coal Tar Research Association. Some problems have been scheduled for extra-mural research, and in this activity the Heriot Watt College, Edinburgh, and the Royal Technical College, Glasgow, are interested.

It is often repeated that coal tar contains upwards of 200 distinct chemical compounds with the implication that coal tar is an Aladdin's Cave packed with riches. In actual practice 85 per cent of the crude tar, which contains 5 per cent of water, is sold in the form of creosote oil and pitch, and blends of these as road tar and coal tar fuel oils. Under 8 per cent is sold in the form of separated chemical compounds, but these latter form the basic raw materials of a vast organic chemical industry. The market value of the dyes, plastics, pharmaceuticals, photographic chemicals, pest control products, disinfectants, and solvents derived by sometimes relatively costly and complicated processes does, in fact, reach a very high figure. It is as a basis for the vast organic chemical industry that these products have a claim to the distinction conferred on them.

"Out of blackness, brilliance"—yes, but the solid revenue of the coal tar industry depends mainly on the markets at home and abroad for its bulk products, namely pitch, creosote, and road tar.

The value of the primary products of tar distillation exported is approximately £6½ million sterling, of which nearly half is to hard-currency countries. It is to be borne in mind that the export of some products is controlled until the basic raw material requirements of other exporting industries, such as plastics, have been met.

REFINERY SAFETY FILMS

General causes of accidents, the proper use of safety equipment, and the necessity for immediately reporting even minor injuries are dealt with in new training films, the first three of an "industrial safety" series, produced by Shell.

Designed primarily to help Shell safety officers, the films are set in an oil refinery. But the hazards and mishaps demonstrated could equally apply elsewhere, and the films, which are both entertaining and instructive, could profitably be viewed by people in many other industries.

The accidents shown in the films are based largely on incidents which have occurred in refineries and the actors and actresses are the men and women who actually do the jobs.

Alert, the first film of the series, demonstrates why accidents happen. Seventy-five per cent of all industrial accidents are caused by lack of concentration or by not bothering to do the job in the right way. For example, young Jack, the lathe worker, daydreams of his girl and the car he would like to be able to take her out in. Harry, normally a conscientious workman, in a hurry to finish an urgently needed part, fails to clamp the metal he intends drilling and does not use his machine guard. Tall, stout Ted and diminutive Bert (a natural pair of comedians, these) use too short a ladder for a repair job, and Ted takes a serious toss.

Carelessness is as good as asking for the ambulance to be called out.

Dressed for the Part, the second film, is concerned with the proper use of safety equipment. Where risks are inherent in a job, safety equipment is always provided. It is common sense to make full use of it. Thus we see the man who has to transfer corrosive acid from rail car to storage tank climbing into his acid-resisting overalls and rubber boots, adjusting his face screen and rubber gloves.

The correct use of the welder's mask is shown. As a practical demonstration of the protection given to the wearer of boots with steel-lined toecaps, a worker is shown smiling nonchalantly while a 14-lb weight is dropped from a height on his steel-protected toes! A worker wearing his safety hat is untroubled when chunks of wood fall on his head.

Starting From Scratch is designed to persuade the worker to report even minor injuries to the medical centre. Hilda neglects a pricked finger; it becomes poisoned. John does not bother about a scratched hand, and when he at last seeks medical attention it means an arm in a sling. As the commentator explains, pain, inconvenience, and loss of time can be prevented if injuries are treated at once by trained staff.

The "Shell" Marketing and Refining Co. are willing to lend copies of these films, which are 16 mm and last for about ten minutes each, to safety officers, and to consider the sale of copies at cost price. Inquiries to Education Section, Publicity Dept., Shell Petroleum Co., St. Helen's Court, London, E.C.3, or to Mr Thacker, "Shell" Refining and Marketing Co., Norman House, London, W.C.2.

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LONDON BRANCH VISITS FUEL RESEARCH STATION

MEMBERS of London Branch visited the Fuel Research Station at Greenwich on March 8. In a matter of three hours the highlights of current developments were expounded in a manner so lucid as to conceal the intensive thought and study that is being put into these projects.

In a building devoted to research on domestic heating appliances, there are four calorimeter rooms, each almost the size of a small living-room and designed to measure the thermal characteristics and efficiencies of heaters and boilers. Constructed only recently, these rooms are probably unique and it is believed that the elusive solution to the problem of the measurement of converted heat has at last been found. (A fuller description was given in these columns in August 1948.)

In another department, work is in hand to improve boiler availability and thus reduce frequency of shutdowns by minimizing the exterior deposits on boilers caused by sulphur, alkalis, and phosphorus in coal.

The best utilization of low-quality coals is also under study in connexion with the supply of synthesis gas for the Fischer-Tropsch process. A method is being developed for the total gasification of high ash-content small-size coal at temperatures above the ash fusion-point so that the ash can be removed while still fluid. The correct type of refractory is important here.

The mysteries of Fischer-Tropsch were unfolded in a fascinating exposition of the developments from the fixed bed (cobalt) catalyst of the Germans, demanding massive equipment, to the fluidized iron catalyst, requiring simpler plant and yielding improved quality products more economically. On purely economic considerations the Fischer-Tropsch process is considered to be of greater value as a source of chemicals than of fuels.

Accounts were given of such diverse activities as the war-time development of flame-thrower fuels; extraction of ester waxes from peat to augment the inadequate supplies of carnauba and montan waxes; and problems which had been solved or remained to be solved in the construction of laboratory apparatus for atmospheric and vacuum fractional distillation. These last were all too brief; but time had marched on and farewells, though sincere, were hurried.

W. P. Butterfield Ltd. have opened a branch office at 36 Cannon Street, Birmingham 2. Mr E. J. Norton will be in charge, and phone number is Midland 5250.

PETROLEUM IN PARLIAMENT

Jet Aircraft Fuels

The Minister of Fuel & Power, in a written reply (April 8), said that British oil refineries would be capable of producing kerosine suitable for jet fighter aircraft. British companies' overseas refineries were also capable of providing substantial quantities of such fuels, and he had no reason to think that sufficient supplies would not be available to meet requirements.

Dollar Petrol

In 1948, U.K. imports of motor and aviation spirit from dollar sources amounted to 43 per cent by value of the total from all sources. The cost, in terms of sterling, was approximately £16 million f.o.b., said Mr Gaitskell on April 14.

Shell-Mex House

Speaking on May 6 in the adjournment debate on conditions in the Civil Service, Mr Geoffrey Cooper said: "If one goes to Shell-Mex House where on one side of the building are the Shell-Mex oil interests and, on the other side, are the offices of the Ministry of Supply, again the contrast from one side of the building to the other is only too noticeable. One has only to compare in that building the Government messengers, with their dreary appearance and downtrodden attitude to life, with the attitude of the men in the Corps of Commissionaires."

"The Science of Petroleum."—The Oxford University Press announces that, in order to bring up to date the four volumes issued in 1938, two additional volumes have been planned provisionally, to be issued in parts. Vol. V will deal with chemistry, physics, and chemical engineering, and Vol. VI with geology, geophysics, production, and distribution. It is hoped to publish Vol. V, Part I (crude oils; chemical and physical properties) in the autumn.

CHEMICAL PHYSICS

The third of the joint meetings (organized on this occasion by the R.I.C.) between the Stanlow Branch of the I.P. and the local sections of the R.I.C. and S.C.I. was held in Chester on March 16, 1949, when G. A. Eltenton, B.A., delivered a paper on "Mass spectrometric determination of free radicals in cracking and combustion".

The work described by the lecturer was investigation of a fundamental character, for which the mass spectrometer was eminently suitable, and much of the groundwork of this research had been laid long before this instrument had developed to its present stage of a refinery control apparatus.

Free radicals may have life periods of as little as 10^{-3} seconds and be present in concentrations as low as 10 p.p.m., hence their detection calls for a highly specialized technique. Special precautions have to be taken to avoid formation of radical ions by electron action during the operation of the mass spectrometer, whilst the existence of isotopes, which can be so helpful in certain types of analysis, can cause difficulties. For instance, the mass of the ethyl radical and that of the C^{13} isotope of ethylene are the same. If "pure" compounds, i.e., containing only one isotope of a given element, could be used for work of this kind it would be of considerable advantage.

The lecturer described the special type of reaction chamber used in the experiments, the furnace being of stainless steel and operating at temperatures in the region of 800° C. He showed some of the results that had been obtained.

The more reactive a radical is, the lower was its life period and concentration, with the result that certain very reactive radicals, e.g., vinyl, could not be detected at all by this method.

Strong evidence for the existence of the radical HO_2 had been obtained. Certain radicals, e.g., OH, whose

presence could be readily detected by ordinary spectrometry, did not lend themselves to easy identification by the mass spectrometer, but this latter instrument could be used for work which could not be tackled by other methods. The mode of use of the mass spectrometer as a research tool was different from that of its employment as a refinery control instrument; in the former case it was important that electron action should not alter the structure of the material under investigation and hence the voltages used were strictly limited, whilst when used for routine analytical purposes it was the object to break down the material under examination into identifiable fragments. Hence, high electron voltages were utilized.

At the close of the paper the lecturer answered numerous questions put by members of the audience, and the meeting concluded with a vote of thanks proposed by Dr G. H. Beavan and seconded by Dr C. B. Davies.

(*N.B.—Readers who are interested in this subject are referred to a paper by Mr Eltenton, "The mass-spectrometric detection of free radicals"*, J. Phys. Colloid Chem., 1948, **52**, 463.)

Colour Computation.—The General Airline and Film Corporation announce an automatic machine which can distinguish more than 100,000,000 colours. This General Airline-Librascope Tristimulus Integrator is said to integrate continuously over the whole visible spectrum and to tell immediately which two colours match or to describe the difference.

"Brief British Passenger Car Data 1949".—Under this title The Associated Ethyl Co. Ltd. has issued a useful booklet giving detailed information on 18 makes and 45 models of British passenger cars. Copies are available from the company at Artillery House, Artillery Row, London, S.W.1.

WORLD OIL RESERVES

In a memorandum recently issued by the Petroleum Information Bureau it is estimated that total proven petroleum reserves in the world at January 1, 1949, amounted to 78,322,000,000 barrels, current and previous figures being:

Estimated proven reserves of crude oil

Jan. 1	*U.S.A.**	*World*
	Million barrels	
1925	5,000	—
1935	12,177	23,000
1945	19,785	64,000
1947	20,874	67,035
1948	21,488	71,312
1949	23,280	78,322

Over 40 per cent of the world total for 1949 is contained in the Middle East, where it is considered that proved reserves are most likely to be substantially increased by future discoveries.

* A.P.I. estimates, excluding condensates and natural gas liquids, which on January 1, 1949, were estimated at 3541 million brls.

N.P.L. GLASSWARE TESTS

From May 1 the National Physical Laboratory will restrict its tests of volumetric glassware to two categories: (1) those admissible for Class A test under existing laboratory regulations; (2) British Standard apparatus for which only one quality of test is appropriate.

Capt. P. S. Robinson (left), retiring Commodore Master of the Anglo-Saxon Petroleum Co.'s fleet, reminisces with R. J. E. Dodds, general manager of the Marine Dept., and Capt. W. Shaw, O.B.E., the new Commodore.

CORRESPONDENCE

To the Editor,

Institute of Petroleum Review.

James Young and the Mineral Oil Industry.

Dear Sir,

During 1948 you published two very interesting articles by Mr E. M. Bailey entitled "James Young—founder of the mineral oil industry" and "The dawn of petroleum refining". These tended to leave the reader with the impression that Young was *the* founder of the petroleum industry rather than *a* founder. This follows from the belief that the Young 1850 patent was a master patent from which the petroleum refining methods derived. Was this the real position, however? The principal claim of the 1850 patent was "*the obtaining of paraffine oil or an oil containing paraffine, and paraffine from bituminous coals*", the source of the oil being emphasized. Had Young believed the treatment of the oil by distillation, etc., to be his basic discovery, he would hardly have worked the Riddings spring by those methods for two years prior to taking out the patent.

During the first half of the nineteenth century there was a considerable amount of interest taken in the derivation of useful products from bituminous materials, and in fact prior to the Young 1850 patent more than twenty British patents were granted for the treatment of bituminous materials by distillation. Young's fame surely rests on the practical details of his method and on his recognition of suitable raw materials. It is very doubtful whether the development of the Pennsylvanian oilfield was dependent to any serious degree upon the Young patent, since the time was ripe for this development, and there were other practicable patented processes available if the need arose.

For example, the Warren de la Rue patent No. 1748 of 1853 was utilized by Price's Patent Candle Co. Ltd. for a number of years for the treatment of crude oil from Burma, burning oil, lubricants, and wax being prepared on a reasonably large scale from 1857 onwards until the availability of cheaper materials from the U.S.A. rendered the continued use of the Burmese product uneconomical.

It would seem desirable while giving all legitimate credit to James Young for his pioneer work, to maintain a sense of historical proportion and recognize that there were others working independently and with success, in the same field.

Yours truly,

C. E. MOLD

Prices Patent Candle Co. Ltd.,
Battersea,
London, S.W.11.
April 20, 1949.

Organic Sulphur Compounds.—The National Bureau of Standards, U.S. Dept. of Commerce, has made available three compounds prepared under the sponsorship of the A.P.I. and the Bureau of Mines. These are: No. 901–5s, C_4H_4S, thiophene; No. 902–5s, C_3H_8S, 2-thiabutane (methyl ethyl sulphide); No. 903–5s, $C_4H_{10}S$, 3-thiapentane (diethyl sulphide). Price is $35 per unit of 5 ml, payable in advance. Orders from laboratories outside the U.S.A. should be sent, in duplicate, to the N.B.S., Washington 25, D.C., U.S.A., quoting number and name.

B.S.I. STANDARDS

Bituminous Roofing Felt, B.S. 747.—Work on a revision of this standard has been started.

Insulating Oil, B.S. 148.—A draft revision of the standard for insulating oil for transformers and switchgear (low viscosity type) has been circulated for comment.

PERSONAL NOTES

P. T. Cox, M.Inst.Pet., succeeded H. S. Gibson as general fields manager of Anglo-Iranian Oil Co. Ltd. on November 18 last. He joined the company in 1924 as a geologist and served in Peru, Venezuela and Colombia, Iran and Kuwait, and in the U.K. During the war he served in the Royal Engineers and was awarded the M.B.E. In 1946 he returned to Iran as manager of the Petroleum Division and was appointed deputy general fields manager in 1947.

Dr A. J. V. Underwood, F.Inst.Pet., has been appointed a member of the committee of the Association of Consulting Engineers.

H. W. Rigden, A.M.Inst.Pet., until recently general refineries manager at Abadan refinery, has returned to England to take up an appointment at Britannic House. He joined the Anglo-Persian Oil Company and went to Abadan in 1923, where he grew up with the refinery. He has been in succession chief chemist, production superintendent, works manager, and finally general refineries manager.

G. L. Coles, F.Inst.Pet., has been appointed chief technical adviser of Shell-Mex and B.P. Ltd. in succession to W. S. Ault, who recently accepted an invitation to become chief chemist of the Shell and Anglo-Saxon Petroleum companies. Mr Coles joined the laboratory staff of Shell-Mex Ltd. in 1925 and was transferred to the Head Office Chemical Department staff in 1928. He was attached to the Technical and Research Department of Shell-Mex and B.P. Ltd. on the formation of that company in 1932 and, in 1939, was appointed assistant manager of Chemical Department in the Petroleum Board.

C. R. Woodfield has been appointed general production manager for the Wakefield group in succession to the late *William Turner*. He is succeeded as manager of the Hayes works by *F. J. Lock*, and *J. G. Bean* has been transferred from the Indian Branch to become works manager of the new installation at Stanlow.

E. H. Collins, recently elected a director of Esso Standard Oil Co., joined the company as a record clerk thirty years ago. He was appointed general manager of marketing operations in 1948 and continues in that position.

Dr A. S. C. Lawrence, F.Inst.Pet., has been awarded the sum of 150 guineas from the Sir George Beilby Memorial Fund for 1948. The award has been made in recognition of his research work in colloid science with special reference to lubrication and fuel oils.

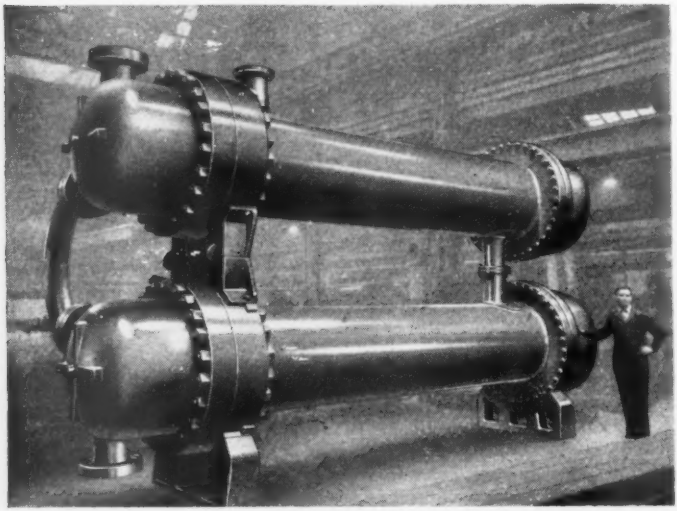
Dr W. H. Garrett, director of production, Monsanto Chemicals Ltd., has been appointed to the Chancellor of the Exchequer's Panel of the Civil Service Arbitration Tribunal.

Prof. Harold Burton has been elected an honorary secretary of the Chemical Society in succession to *Sir John Simonsen*.

Fine Chemicals.—British Chemicals & Biologicals Ltd. have recently issued a list of over 100 fine chemicals which are available for research and development work. Copies are available from 43 Regent Street, Loughborough.

A 108-ton all-steel welded fractionating column, measuring 83 ft 8 in by 10 ft 4 in, being lowered into the River Thames prior to being towed across the North Sea to the Royal Dutch Shell refinery at Pernis, near Rotterdam.

HEAT EXCHANGE EQUIPMENT



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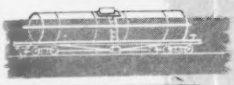

ALCOHOLS AND ESTERS

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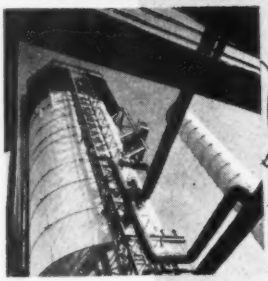

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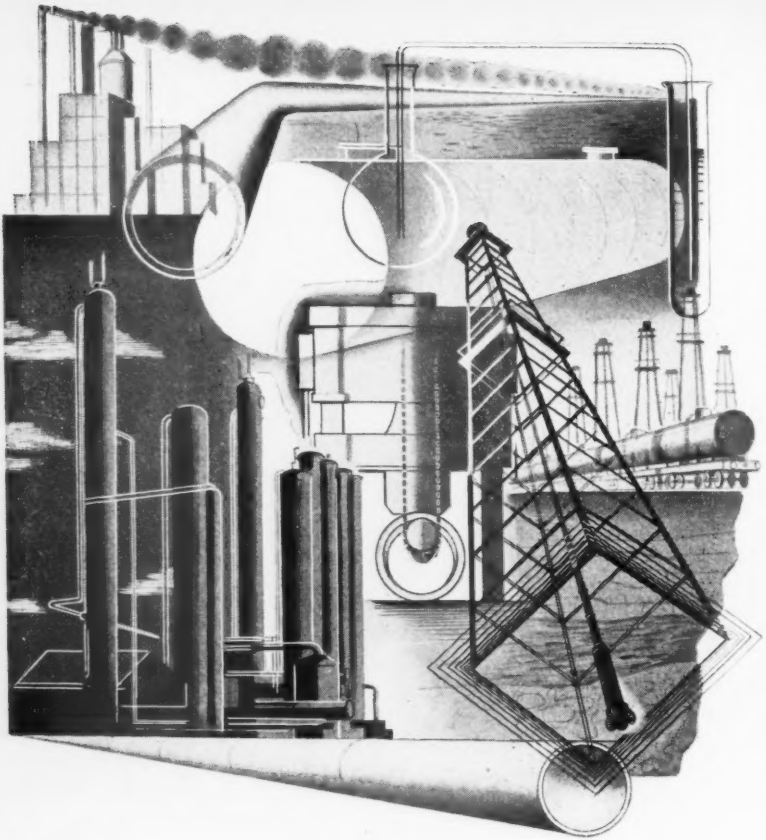

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